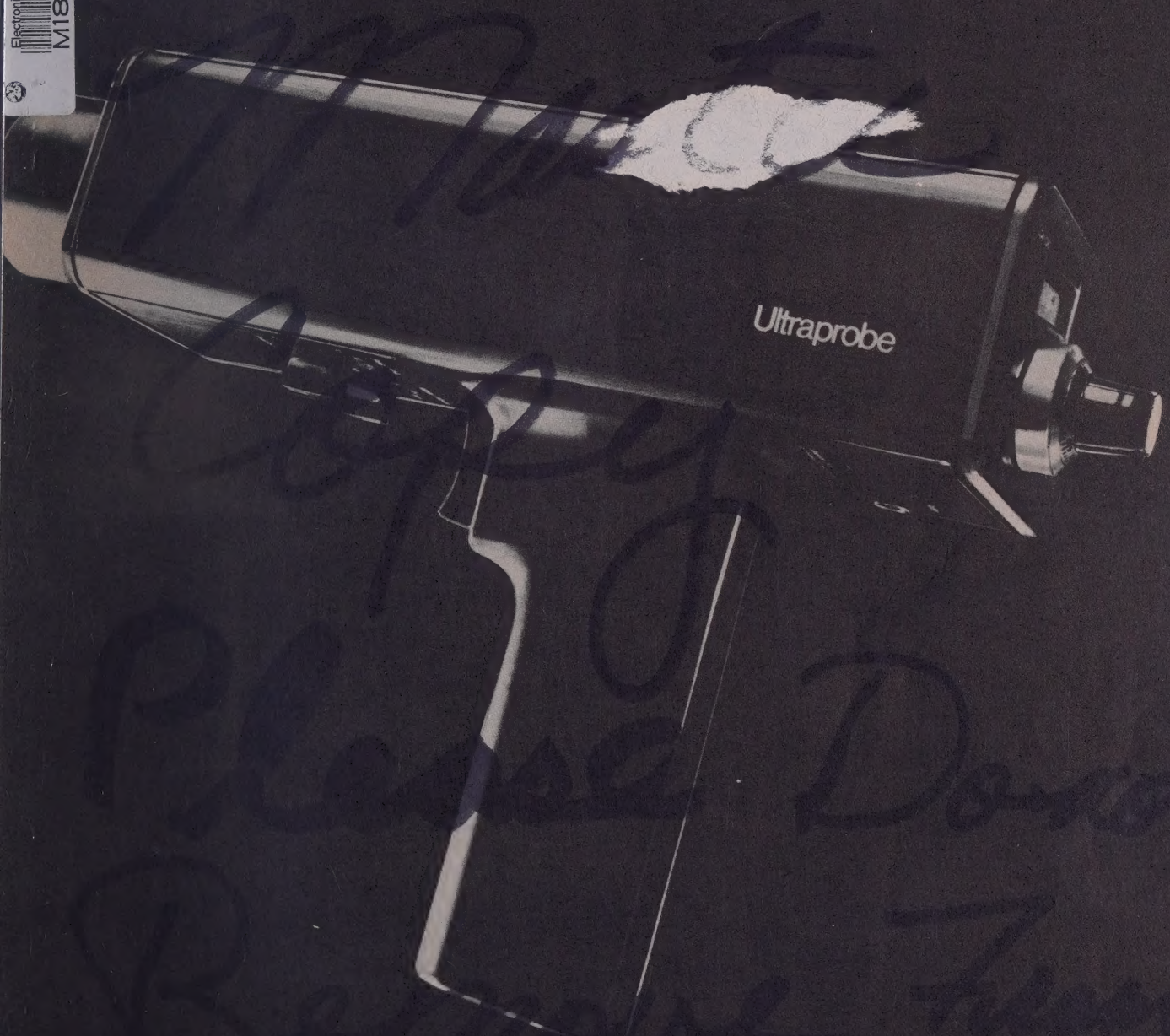
Electronic Services, Hayward, Ca.
M18524X

ULTRAPROBE



INSTRUCTION MANUAL

TABLE OF CONTENTS

	Page
COMPONENTS	1
A description of the various items in the Ultraprobe Kit and how they function.	
1. Metered Pistol Housing	1
2. Trisonic Scanning Module	3
3. Contact (Stethoscope) Module	4
4. Headset	4
5. Tone Generator	4
6. Auxiliary Chart Recorder and Tape Recorder	5
ULTRAPROBE APPLICATIONS	6
How to use the Ultraprobe in a variety of leak detection applications.	
1. LEAK DETECTION	
Testing pressure and vacuum systems for leakage, and for electric arc/corona discharge	
A. How to Locate Leaks	7
B. Overcoming Difficulties	8
- - Competing Ultrasounds	8
- - Low Level Leaks	8
C. Frequency Tuning	8
D. Electric Arc/Corona Detection	8
E. The Tone Test	9
A unique method for non-destructive testing applicable to a wide range of items: e.g., containers, pipes, heat exchangers, and doors and windows	
2. MONITORING BEARING WEAR	10
Detecting Bearing Failure	11
3. MECHANICAL TROUBLE SHOOTING	12
Monitoring Operating Equipment	12
4. LOCATING FAULTY STEAM TRAPS	13
How each trap fails and what to listen for:	
- - Inverted Bucket Traps	13
- - Float and Thermostatic Traps	13
- - Thermodynamic (Disc) Traps	13
- - Thermostatic (Bellows & Bimetallic) Traps	14
5. FINDING FAULTY VALVES	14
6. MISCELLANEOUS PROBLEM AREAS	15
A. Underground Leaks	15
B. Leakage Behind Walls	15
C. Blockage in Pipes	15
ULTRASOUND TECHNOLOGY	16
What ultrasound is and how it works, and how it is utilized by the Ultraprobe	
The Basics of Sound	17

The ULTRAPROBE 2000 opens the vista of preventative maintenance as never before. This multifaceted instrument provides testing capability ranging from simplistic forms of leak detection to extremely sophisticated methods of mechanical analysis.

It is a testing laboratory that fits in the palm of your hand.

Before you begin testing, it is advisable to familiarize yourself with the basic components of your kit.

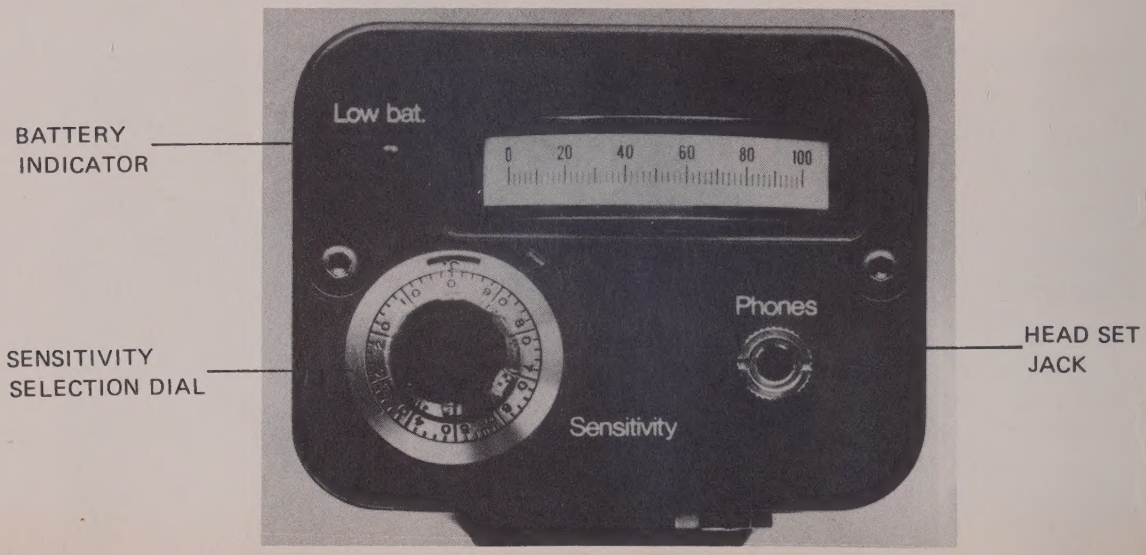
1. METERED PISTOL HOUSING

The main component of the Ultraprobe is its pistol housing. From back to front, let's examine each part.

A. Meter: This ballistic meter has intensity increments of from 0 to 100. The 50 divisions reflect intensity changes only: the more intense the ultrasonic signal, the higher the reading.

B. Battery Level Light: This red light turns on only when the batteries need recharging.

C. Sensitivity Selection (calibration) Dial: The increments on this dial allow for 500 individual setpoints. There are 3 sets of numbers. The outer window reflects the whole digit and reads from 0 to 10. The inside digits are for fine tuning and these gradations are smaller gradations shown as lines which represent 2 divisions each. As the numbers go UP in value, the sensitivity of the instrument also goes up. The maximum sensitivity level is 10, the minimum sensitivity level is 0.0. On the sensitivity selection switch is a LOCK lever. This allows a user to lock the sensitivity selection and thereby prevent it from being moved inadvertently. To lock the sensitivity selection, rotate the lever clockwise; to release the lock, rotate the lever counter-clockwise.



D. Head Set Jack: This is where you plug in the headset. Should a tape recorder be utilized, this is where the cord for the tape recorder is inserted.

TURN THE MAIN HOUSING OF THE ULTRAPROBE 2000 UP-SIDE DOWN AND YOU WILL SEE:

E. Trigger Switch: The Ultraprobe is always "off" until the trigger switch is pressed. To operate, simply press the trigger; to turn the instrument off, release the trigger.

F. Frequency Adjust Dial: There are numbers ranging from 100 kHz down to 20 kHz. These represent the range of frequency selection capable with the Ultraprobe. These frequencies may be "tuned in" when performing mechanical analysis with the contact (stethoscope) probe (for more, refer to description of contact probe). There is also a detented position, labeled "fixed band". This selection automatically locks the circuitry of the Ultraprobe into the peak response of the transducers of either the contact (stethoscope) module or the Trisonic scanning module. This position is most often utilized. It is extremely useful in ambient noise situations. Since it allows the Ultraprobe an extremely narrow frequency response, most conflicting ultrasound noises will be minimized. This makes leak location easier and provides for fast, accurate location of problem sounds in operating machinery (for more information, refer to the section on MECHANICAL ANALYSIS).

G. Meter Selection: There are three positions for this dial.

1. Log: this selection allows the meter to respond in a real-time, instant, mode. This selection is used when fast, instant meter response is needed --- as in leak detection.

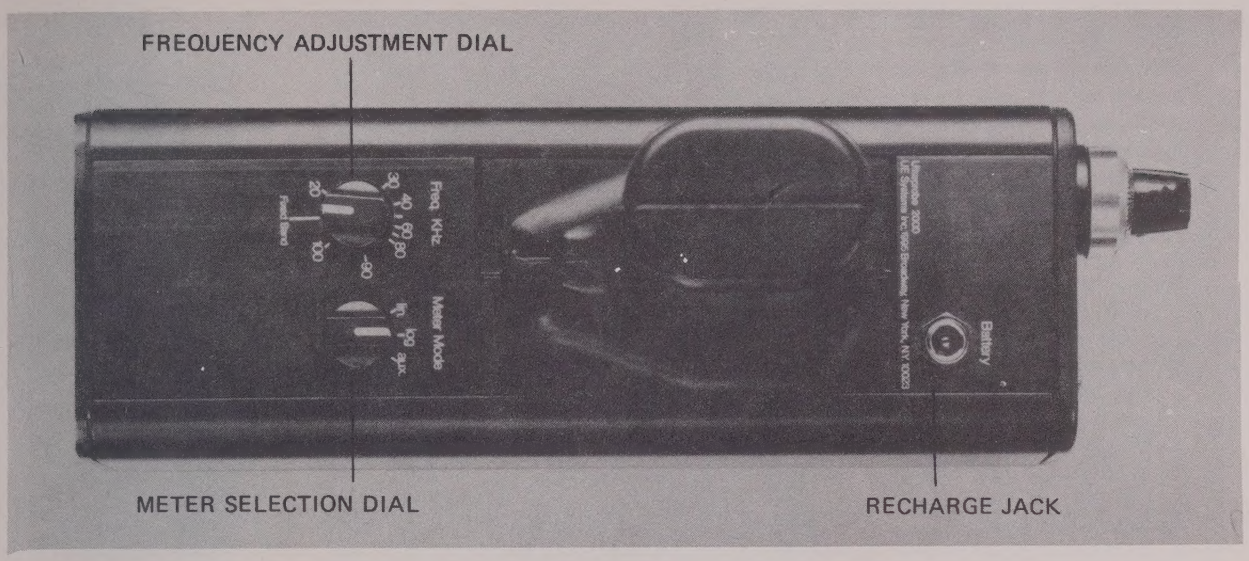
2. Lin: this selection, linear, can be considered a slow response. It eliminates the high and low swings of the meter and averages the response for a more measurable result. This selection is utilized when monitoring bearings or in mechanical analysis when too rapid a meter response might be confusing to the operator.

3. aux: this is the auxiliary position which is to be used ONLY when a specially adapted instrument is to be interfaced with the Ultraprobe. One such instrument is U.E. Systems' chart recorder. The dial WILL NOT turn to this position unless the Ultraprobe has been adapted to do so at the factory. DO NOT FORCE dial to this position.

A WORD ABOUT BATTERY CARE

Ni-cad batteries are relatively easy to maintain. For trouble free usage, it is necessary to understand your battery.

1. Ni-cads have a memory. They can "learn" to discharge at shorter intervals than they should. (e.g. a battery used infrequently will eventually fail during prolonged use.)



2. Exercise your battery. In order to keep your battery running at optimum, it is suggested that every two weeks:
   a. turn Ultraprobe and Tone Generator on until the batteries have drained
   b. charge batteries for at least 7 hours

H. Recharge Jack: This jack is where the recharger is plugged in. A word about the recharger. The recharger is designed to plug into a standard electrical receptacle. There are two wires from the recharger; either plug will fit the Ultraprobe jack or the Tone Generator jack (see TONE GENERATOR for more information).

When recharging: 1. Plug in main plug to electrical outlet.
2. Plug in either of two plugs into recharger jack of Ultraprobe and of Tone Generator.

WHEN TO RECHARGE: When the red low level indicator light goes on, IMMEDIATELY recharge the Ultraprobe for 8 hours. If the instrument is not used for a week or more, recharge it for 4 hours. If the Ultraprobe is not used for a few days, it can be used without recharging, however, for best results, it is advisable to recharge it as a "booster" for about an hour before using. To prolong the life of the ni-cad batteries, it is advisable NOT to continuously have the instrument on charge when it is not in use.

2. TRISONIC SCANNING MODULE

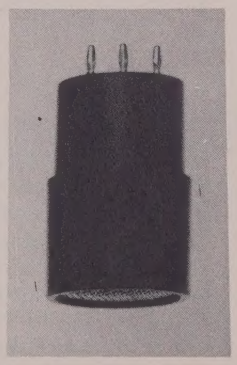
This module is utilized to receive air-borne ultrasound such as the ultrasounds emitted by pressure leaks and electrical discharges. There are three prongs at the rear of the module. For placement, align the prongs with the three corresponding holes in the front end of the metered pistol housing and plug in.

The Trisonic Scanning Module has a phased array of three piezoelectric transducers to pick up the air-borne ultrasound. This phased array focus the ultrasound on one "hot spot" and effectively intensifies the signal so that minute ultrasonic emissions may be detected.

To use the Trisonic Scanning Module:

1. Plug in to front end.
2. Select the LOG position on the meter selection dial
3. (most often) position the frequency selection dial to the "fixed-band" mode.
4. Start with the sensitivity selection dial at maximum (10).
5. Start to scan the test area.
   a. The method of air borne detection is to go from the "gross to the fine". If there is too much ultrasound in the area, reduce the sensitivity, place the RUBBER FOCUSING PROBE (described below) over the scanning module and proceed to follow the test sound to its' loudest point, constantly reducing the sensitivity and following the meter.

RUBBER FOCUSING PROBE: The rubber Focusing Probe is a cone-shaped rubber shield. It is used to block out stray ultrasound and to assist in narrowing the field of reception of the Trisonic Scanning Module. To use, simply slip it over the front of the scanning module.



Trisonic Scanning Module

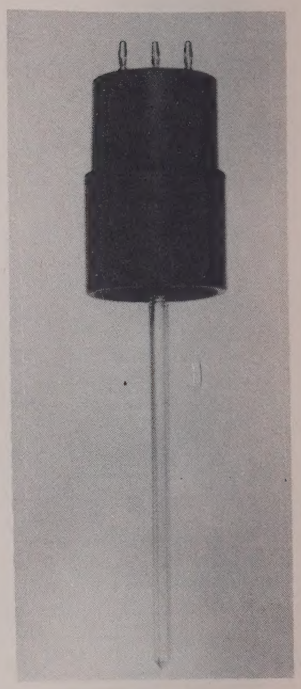
3. CONTACT (STETHOSCOPE) MODULE

This is the module with the metal rod. This rod is utilized as a "wave-guide" in that it is sensitive to ultrasound that is generated internally such as within a pipe, bearing housing, steam trap or wall. Once stimulated by ultrasound, it transmits the signal to a piezoelectric transducer located directly in the module housing. This module is shielded to provide protection from stray RF waves that have a tendency to effect electronic receiving. This module can be effectively utilized in practically any environment ranging from airports to broadcasting towers. It is equipped with low noise amplification to allow for a clear intelligible signal to be received and interpreted.

To use the Stethoscope Module:

1. Align the pins located at the rear of the module with the three holes in the front end of the Metered Pistol Housing and plug in.
2. For detecting leaks in valves, steam traps, etc., position the meter selection dial to LOG. If performing mechanical analysis, bearing monitoring, etc., select the LIN mode on the meter selection dial.
3. For general use, position the frequency selection dial to "Fixed-Band". For problem solving, i.e. finding a problem sound, refer to selection on Mechanical Analysis.
4. Touch test area.
5. As with scanning module, go from the "gross" to the "fine". Start at maximum sensitivity on the sensitivity selection dial and proceed to reduce the sensitivity until a satisfactory sound and meter level is achieved.

At times it may be necessary to utilize the stethoscope probe with the sensitivity level at or near maximum. During this type of situation stray ultrasound may interfere with clear reception and be confusing. If this occurs, place the RUBBER FOCUSING PROBE over the Stethoscope probe to insulate against the stray ultrasound.



Contact Module

STETHOSCOPE EXTENSION KIT: This consists of three metal rods that will enable a user to reach up to 31 additional inches with the Stethoscope Probe. To use:

1. Remove the Stethoscope Module from the Metered Pistol Housing.
2. Unscrew the metal rod in the Stethoscope Module.
3. Look at the thread of the rod you just unscrewed and locate a rod in the kit that has the same size thread – this is the "base piece".
4. Screw the Base Piece into the Stethoscope Module.
5. If all 31" are to be utilized, locate the middle piece. (This is the rod with a female fitting at one end) and screw this piece into the base piece.
6. Screw third "end piece" into middle piece.

6a If a shorter length is desired, omit step 5 and screw "end piece" into "Base Piece".

4. HEADSET

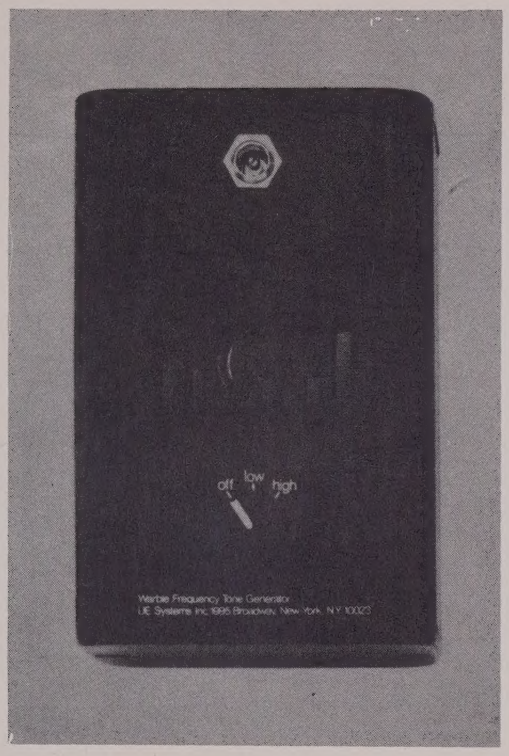
This heavy duty headset is designed to block out intense sounds often found in industrial environments so that the user may easily hear the sounds received by the ULTRAPROBE. To use, simply plug the headset cord into jack on the metered pistol housing, and place the headphones over your ears. If a hard hat is worn, place the head-rest part of the headset around the back of your head and place the headphones over your ears.

5. TONE GENERATOR

The Tone Generator is an ultrasonic transmitter designed to flood an area with ultrasound. It is used for a special type of leak test. When placed inside an empty container or on one side of a test item, it will flood that area with an intense ultrasound that will not penetrate any solid but will flow through any existing fault or void. By scanning with the Trisonic Scanning Module, empty containers such as pipes, tanks, windows and doors can be instantly checked for leakage. This Tone Generator is a WARBLE TONE GENERATOR. It sweeps a number of ultrasonic frequencies in order to provide for consistency of testing in any material and in practically any situation.

To use the WARBLE TONE GENERATOR:

1. Turn Tone Generator on by selecting either "LOW" for a low amplitude signal (usually recommended for small containers) or "HIGH" for high amplitude.
   When the Tone Generator is on, a red light flickers.



Tone Generator

2. Place the Tone Generator within the test item amd seal the test item. If the item is to be tested is a gasket around a window or door, place it on one side of the door or window, close it and proceed to scan on the opposite side. To test the condition of the Tone Generator battery, set to the LOW INTENSITY position and listen to the sound through the Ultraprobe in the FIXED BAND mode. A smooth continuous warbling should be heard. If a "beeping" is heard instead, then a full recharge of the Tone Generator is indicated.

To charge the WARBLE TONE GENERATOR:
Follow directions in 1-H RECHARGE JACK. (Page 3)

6. AUXILIARY CHART RECORDER

The Ultraprobe can be adapted for use with the UECR-2001 Chart Recorder. NOTE: DO NOT ATTEMPT TO USE a chart recorder unless your instrument has been specifically adapted for chart recorder use. The Ultraprobe will only operate with UE APPROVED CHART RECORDERS. To obtain information regarding outfitting your instrument for chart recorder use, contact your local sales representative, or call our factory.

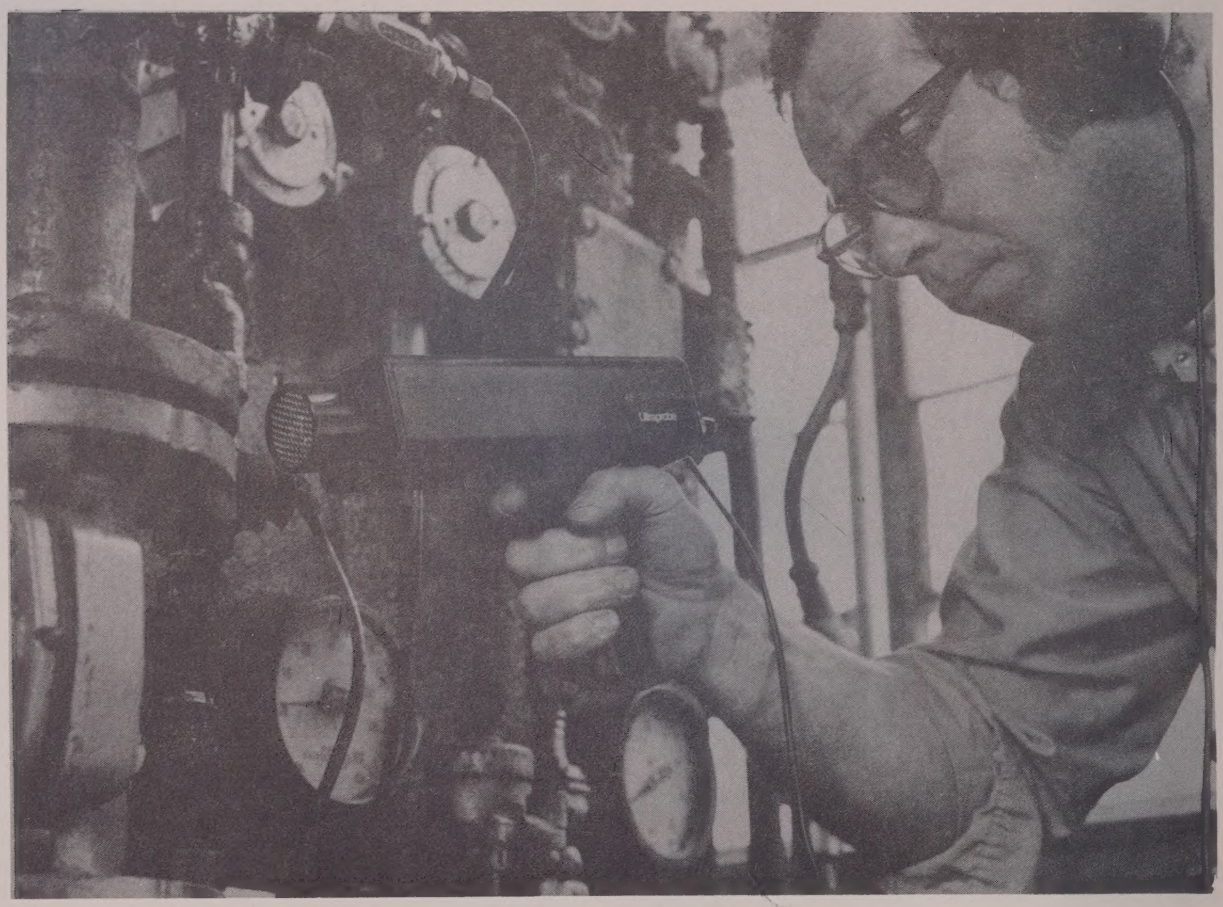
FOR CHART RECORDER HOOK-UP:

1. Select auxiliary mode on Meter Selection Dial.
2. Plug chart recorder into chart recorder (aux) jack.
3. Select frequency to be monitored. You may test as many frequencies as you wish.
4. Refer to specific chart recorder instructions in order to operate your chart recorder.

TAPE RECORDER

Often it is helpful to establish a library of sounds. These sounds can be recorded on tape and used for future reference as well as for training new personnel.

Your Ultraprobe must be adapted for tape recorder usage. Should you wish to have the Ultraprobe adapted for tape recorder use, contact our factory with details about the specific tape recorder to be used.

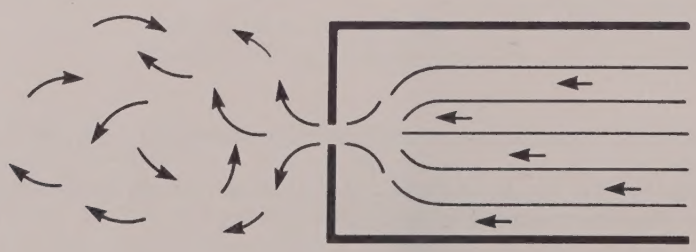


ULTRAPROBE APPLICATIONS

1. LEAK DETECTION

This section will cover air-borne leak detection of pressure and vacuum systems. (For information concerned with internal leaks such as in Valves and Steam traps, refer to the appropriate sections.)

What produces ultrasound in a leak? When a gas passes through a restricted orifice under pressure, it is going from a pressurized laminar flow to low pressure turbulent flow. (Fig. 1.) The turbulence generates a broad spectrum of sound called "white noise" There are ultrasonic components in this white noise. Since the ultrasound will be loudest by the leak site, the detection of these signals is usually quite simple.

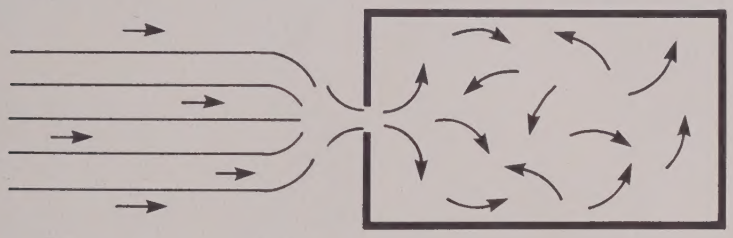


PRESSURE LEAK
FIGURE 1

A leak can be in a pressurized system or in a vacuum system. In both instances, the ultrasound will be produced in the manner described above. The only difference between the two is that a vacuum leak will usually generate less ultrasonic amplitude than a pressure leak of the same flow rate. The reason for this is that the turbulence produced by a vacuum leak is occurring within the vacuum chamber while the turbulence of a pressure leak is generated in the atmosphere. (Fig. 2.)

What type of gas leak will be detected ultrasonically? Generally any gas, including air, will produce a turbulence when it escapes through a restricted orifice. Unlike gas specific sensors, the Ultraprobe is sound specific. A gas specific sensor is limited to the particular gas it was designed to sense (e.g., freon). The Ultraprobe can sense any type of gas due to the ultrasonic nature of most leakage.

Because of its versatility, the Ultraprobe may be utilized in a wide variety of leak detection. Pneumatic systems may be checked, pressurized cables, such as those utilized by telephone companies, may be tested. Air brake systems on railroad cars, trucks and buses may be checked. Tanks, pipes and tubes are easily tested for leakage by pressurizing them. Vacuum systems, turbine exhausts, diesel engine fuel suction systems, vacuum chambers, material handling systems, can all easily be tested for leakage by listening for the turbulence of the leak.



VACUUM LEAK
FIGURE 2

A. HOW TO LOCATE LEAKS

1. Use the TRISONIC SCANNING MODULE
2. Select the LOG setting on the meter selection dial
3. Use "fixed-band" position on the Frequency selection dial. If too much background noise is present, try 95 kHz or 60 kHz.
4. Start off with the sensitivity selection at 10 (Maximum)
5. Begin to scan by pointing the module towards the test area. The procedure is to go from the "gross" to the "fine" – more and more subtle adjustments will be made as the leak is approached.
6. If there is too much ultrasound in the area, reduce the sensitivity setting and continue to scan.
7. If it is difficult to isolate the leak due to competing ultrasound, place the RUBBER FOCUSING PROBE over the scanning module and proceed to scan the test area.
8. Listen for a "rushing" sound while observing the meter.
9. Follow the sound to the loudest point. The meter will show a higher reading as the leak is approached.
10. In order to focus in on the leak, keep reducing the sensitivity setting until you are able to confirm a leak.

    TO CONFIRM A LEAK:

    Position the rubber focusing probe (if it is on the scanning module) close to the suspect leak site and move it, slightly, back and forth, up and down, If the leak is at this location, the sound will increase and decrease in intensity as you sweep over it.

B. OVERCOMING DIFFICULTIES

1. Competing Ultrasounds

If competing ultrasounds make it difficult to isolate a leak, there are two approaches to be taken:

a. Manipulate the environment. This procedure is fairly straight forward. When possible, turn off the equipment that is producing the competing ultrasound. If this is not possible, and the ultrasound is difficult to work around even with the rubber focusing probe, then utilize some ultrasound reflecting material such as a welder's curtain to isolate the test area.

b. Manipulate the instrument. If environmental manipulation is not possible, try to get as close to the test site as possible, and manipulate the instrument so that it is pointing away from the competing ultrasound, and isolate the leak area by reducing the sensitivity of the unit and by pushing the tip of the rubber focusing probe up to the test area, checking a small section at a time. In some extreme instances, when the leak check is difficult in the fixed band mode of the frequency selection dial, try to "tune in" to the leak sound by "tuning out" the problem sound. In this instance, adjust the frequency selection dial until the background sound is minimized and then proceed to listen for the leak.

A word about FIXED-BAND.
This selection is quite unique in that it automatically tunes the Ultraprobe in to responding to the peak response of the Trisonic Scanning Module's phased array of crystals. In practically all leak detecting situations, this selection will eliminate many problems with competing ultrasounds. For this reason it is suggested that all leak detection be initiated with the Fixed Band selection.

2. Low Level Leaks

In ultrasonic inspection of leakage, the amplitude of the sound often depends upon the amount of turbulence generated at the leak site. The greater the turbulence, the louder the signal, the less the turbulence, the lower the intensity of the signal. When a leak rate is so low that it produces little, if any turbulence that is "detectable" it is considered "below threshold". If a leak appears to be of this nature,

1. build up the pressure (if possible) to create greater turbulence.
2. utilize LIQUID LEAK AMPLIFIER.

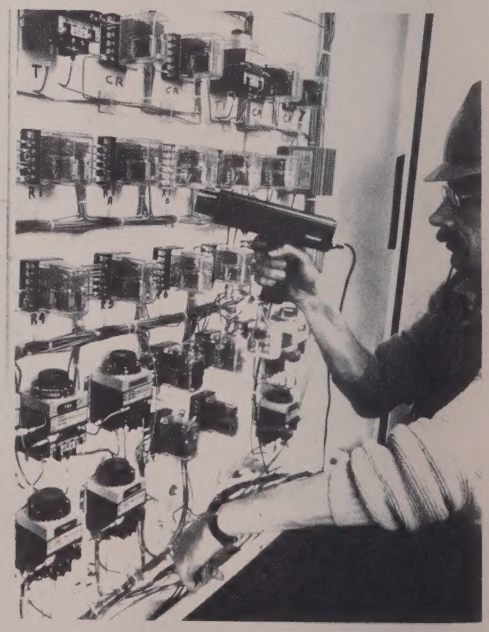
LIQUID LEAK AMPLIFIER is a liquid substance that has special chemical properties. When it comes in contact with a low flow of gas, it forms a large number of small "soda-like" bubbles that collapse as soon as they form. This collapsing produces an ultrasonic shock wave that is heard as a crackling sound in the headphones. This method is capable of obtaining successful leak checks in systems with leaks as low as 10^{-6}cc/sec

C. FREQUENCY TUNING

If there are situations where a signal may be difficult to isolate, it may be helpful to utilize the **Frequency** Tuning Dial. Point the Ultraprobe toward the test area and gradually adjust the frquency tune dial until the weak signal appears to be louder and then follow the basic detection methods previously outlined.

D. ELECTRIC ARC/CORONA DETECTION

When electricity escapes in high voltage lines or when it "jumps" across a gap in an electrical connection, it disturbs the air molecules around it and generates ultrasound. In some instances this sound will be perceived as a crackling sound, in other situations it will be heard as a buzzing sound.



The method for detecting electric arc and corona leakage is similar to the procedure outlined in leak detection. Instead of listening for a rushing sound, a user will listen for a crackling or buzzing sound. In some instances, as in trying to locate the source of radio/TV interference or in substations, the general area of disturbance may be located with a gross detector such as a transistor radio or a wide-band interference locator. Once the general area has been located, the scanning module of the Ultraprobe is utilized with a general scan of the area. The sensitivity is reduced if the signal is too strong to follow on the meter until the loudest point is located. In some instances, it might be necessary to climb a pole and simulate windy day conditions by striking the entire structure with a sledge hammer to create vibration.

In substations, components such as insulators, transformers and bushings may be tested.

On lower voltage systems, a quick scan of bus bars often will pick up a loose connection. Checking junction boxes can reveal arcing. If there is a problem isolating a subtle arc, jiggle the wires in the junction box so that the loose wire will arc. As with leak detection, the closer one gets to the leak site, the louder the signal. If power lines are to be

inspected and the signal does not appear to be intense enough to be detectable from the ground, incorporating a lift such as a "cherry picker" to get closer to the test area will be useful.

E. TONE TEST

The Tone Test is an ultrasonic method for non-destructive testing which is faster and easier than conventional methods utilizing air pressure or water, yet provides complete accuracy. This ultrasonic test is applicable to a wide range of items, including: CONTAINERS, TUBES, PIPES, HEAT EXCHANGERS, WELDS, GASKETS, SEALS. And is also highly effective in locating air infiltration around DOORS, WINDOWS, AND HATCHES.

The test is conducted by placing an ultrasonic transmitter, called TONE GENERATOR, inside (or on one side) of the test item. Instantly, the powerful pulse-signal from the TONE GENERATOR floods the test item and penetrates any existing void or fault. Even thin spots in certain metals can be vibrated by the signal. By scanning for sonic penetration on the outside (or opposite side) of the test item with the Ultraprobe, any existing leak is quickly heard and pinpointed.

The Tone Test incorporates two basic components: an ultrasonic transmitter TONE GENERATOR, and the Trisonic Scanning Module in the Ultraprobe. To conduct the test:

1. Make certain the test item has no fluids or contaminants such as mud, sludge, etc., that can block the path of the transmitted ultrasound.
2. Place the Tone Generator within the container, (if it is a room, door or window to be tested, place the Tone Generator on one side) and close, or seal so that the Tone Generator is enclosed within.

   NOTE: The size of the test area will determine the amplitude selection of the Tone Generator. If the item to be tested is small, select the LOW position. For larger items, use the HIGH position.

3. Scan the test area with the Ultraprobe as outlined in LEAK DETECTION procedure. (i.e., start with the sensitivity selection at 10 and proceed down.)
   a. Start with the meter mode in LOG
   b. Select Fixed-Band on the frequency select dial.

When positioning the Tone Generator, generally place the transducer facing the most crucial test area. If a general area is to be checked, position the Tone Generator so that it will cover as wide an area as possible by placing it in the "middle" of the test item.

How far will the sound travel? The Tone Generator is designed to cover approximately 4000 cubic feet of space. This is slightly larger than the size of a tractor trailer. Placement is dependent upon such variables as the size of the leak to be tested, the thickness of the test wall and the type of material tested (i.e. is it sound absorbant or sound reflective?)

Do not use the Tone Test in a complete vacuum.

Ultrasound will not travel in a vacuum. Sound waves need molecules to vibrate and conduct the signal. There are no movable molecules in a complete vacuum.

If a partial vacuum is to be drawn where there are still some air molecules to vibrate, then the Tone Test may be implemented successfully.

In a laboratory, a form of the Tone Test is utilized in seal leaks of an electron beam microscope. The test chamber has been fitted with a specially designed transducer to emit the desired tone and a partial vacuum is created. A user then scans all seams for sonic penetration. The Tone Test has also been effectively utilized to test tanks before they are put on line, piping, refrigerator gaskets, caulking around doors and windows for air infiltration testing, heat exchangers for leaking tubes and on aircraft to test for problems associated with decompression.

2. MONITORING BEARING WEAR

Ultrasonic inspection and monitoring of bearings is by far the most reliable method for detecting incipient bearing failure. The ultrasonic warning appears prior to a rise in temperature or an increase in driving torque. Ultrasonic inspection of bearings is useful in recognizing:

a. the beginning of fatigue failure
b. brinelling of bearing surfaces
c. flooding of or lack of lubricant.

In ball bearings, as the metal in the raceway, roller or bearing balls begin to fatigue, a subtle deformation begins to occur. This deforming of the metal will produce an increase in the emission of ultrasonic sound waves.

When testing, changes in amplitude of from 12 to 50 times the original reading is indication of incipient bearing failure. When a reading exceeds any previous reading by 10 to 20 db, it can be assumed that the bearing is in the failure mode.

This information was originally discovered through experimentation performed by NASA on ball bearings. In tests performed while monitoring bearings at frequencies ranging from 24 through 50 kHz, they found that the changes in amplitude indicate incipient bearing failure before any other indicators including heat and vibration changes. (An ultrasonic system based on detection and analysis of modulations of bearing resonance frequencies can provide subtle detection capability; whereas conventional methods are incapable of detecting very slight faults). As a ball passes over a pit of fault in the race surface, it produces an impact. A structural resonance of one of the bearing components vibrates or "rings" by this repetitive impact. The sound produced is observed as an increase in amplitude in the monitored frequencies of the bearing.

Brinelling of bearing surfaces will produce a similar increase in amplitude due to the flattening process as the balls get out of round. These flat spots also produce a repetitive ringing that is detected as an increase in amplitude of monitored frequencies.

The ultrasonic frequencies detected by the Ultraprobe are reproduced as audible sounds. This "heterodyned" signal can greatly assist a user in determining bearing problems. When listening, it is recommended that a user become familiar with the sounds of a good bearing. A good bearing is heard as a rushing or hissing noise. Crackling or rough sounds indicate a bearing in the failure stage. In certain cases a damaged ball can be heard as a clicking sound whereas a high intensity, uniform rough sound may indicate a damaged race or uniform ball damage. Loud rushing sounds similar to the rushing sound of a good bearing only slightly rougher, can indicate lack of lubrication.

A qualitative indication of lack of lubrication can be observed as the amplitudes at all prominent frequencies monitored begin to increase notably.

Detecting Bearing Failure

There are two basic procedures of testing for bearing problems:

COMPARATIVE AND HISTORICAL. The comparative method involves testing two or more similar bearings and "comparing" potential differences. Historical testing requires monitoring a specific bearing over a period of time to establish its history. By analyzing bearing history, wear patterns at particular ultrasonic frequencies become obvious which allows for early detection and correction of bearing problems.

PROCEDURE FOR BEARING HISTORY:

1. Use contact (stethoscope) module
2. Select LIN on meter selection dial.
3. Select desired frequency on FREQUENCY SELECTION DIAL. (If only one frequency is to be monitored, consider using the FIXED BAND mode for ease and consistency.
4. Select a "test spot" on the bearing housing and mark it for future reference either by denting it with a center punch or with paint. Touch that spot with the contact module. In ultrasonic sensing, the more mediums ultrasound has to travel through, the less accurate the reading will be. Therefore be sure the contact probe is actually touching the bearing housing. If this is difficult, touch a grease fitting or touch as close to the bearing as possible.
5. For consistency, always approach the test spot at the same angle.
6. Reduce sensitivity (if unsure of this procedure, refer to SENSITIVITY SELECTION DIAL) until the meter reads 50.
7. Listen to bearing sound through headphones to hear the "quality" of the signal for proper interpretation. (Refer to page 10 for discussion of audio interpretation.)
8. Note frequency meter reading and sensitivity selection on your Bearing History Chart (See Reference Guide 1)

8a. Compare this reading with previous (or future readings) by referring to the Ultraprobe Attenuator Transfer Curve (See Reference Guide 2)
NOTE: Increases of from 10 to 20 db indicate the bearings has entered a failure mode.

If lack of lubrication is suspected, after lubricating, re-test. If readings do not go back to original levels, consider bearing in the failure mode.

9. (OPTIONAL) In some instances it may be desirable to monitor 2 or more frequencies to provide additional wear data. Some commonly tested frequencies are 28 kHz and 32 kHz.

FOR COMPARATIVE TEST

1. Use basic procedure as outlined above in steps 1-7.
2. Select same type bearings under similar load conditions and same rotational speed.
3. Approach the bearings at the same angle, touching approximately the same area on the bearing housing.
4. Compare differences utilizing Ultraprobe Attenuate Transfer Curve and by interpreting audio differences.

NOTE: This method often ultimately relies on experience for interpretation.

3. MECHANICAL TROUBLE SHOOTING

As operating equipment begins to fail due to component wear, breakage or misalignment, sonic and more importantly, ultrasonic shifts occur. The accompanying sound pattern changes can save time and guess work in diagnosing problems if they are adequately monitored. Therefore, an ultrasonic history of key components can prevent unplanned down-time. And just as important, if equipment should begin to fail in the field, THE ULTRAPROBE can be extremely useful in trouble shooting problems.

TROUBLE SHOOTING:

1. Use the contact (stethoscope) module
2. Set desired meter mode.
   a. LIN selection where a slow, averaging meter response is required. Generally this selection is utilized when wide meter swings caused by excessive ultrasonic activity might effect meter interpretation.
   b. LOG selection when instant meter response is desired. This is useful in analyzing certain operating mechanical functions such as valve operation.
3. Start probing with Frequency Selection Dial in FIXED BAND mode.
4. Touch test area(s): listen through headphones and observe the meter.
5. Adjust sensitivity until mechanical operation of the equipment is heard clearly and the meter can fluctuate.
6. Probe equipment by touching various suspect areas.
7. If competing sounds in equipment being tested present a problem, try to "tune in" to the problem sound by:
   a. probing equipment until the potential problem sound is heard.
   b. adjust Frequency Selection Dial by rotating it (counter-clockwise) slowly until the problem sound is heard more clearly.
8. To focus in on problem sounds, while probing, reduce sensitivity gradually to assist in locating the problem sound at its loudest point. (This procedure is similar to the method outlined in LEAK LOCATION, i.e., follow the sound to its loudest point.)

MONITORING OPERATING EQUIPMENT

In order to understand and keep ahead of potential problems in operating equipment, it is necessary to establish base data and observe shifts in that data. The data can be compiled from meter readings, chart recordings and even tape recordings (for tape recordings it will be necessary to order a U.E. Tape Recorder Adaptor Kit. This can be easily arranged through your local salesman or directly through the factory. For chart recording it will be necessary to have your Ultraprobe converted at the factory.)

PROCEDURE:

1. Select key locations to be monitored and make permanent reference marks for future testing by either marking with a center-punch or with paint.
2. Follow steps 1-5 as outlined above in the Trouble Shooting section.
3. Select one (or more) frequency(ies) for each test spot.
4. On a chart note:
   a. equipment
   b. location
   c. date
   d. meter mode (LIN/LOG)
   e. frequency selection(s)
   f. sensitivity level
   g. meter reading

NOTE: In diagnosing any type of mechanical equipment, it is important to understand how that equipment operates. Being able to interpret sonic changes is dependent on a basic understanding of the operations of the particular equipment being tested. As an example, in some reciprocal compressors, the diagnosis of a valve problem in the inlet manifold is dependent on recognizing the distinctive clicking sound of a good valve vs. the muffled click of a valve in a "blow-by" mode.

In gear boxes, before missing gear teeth may be detected as an abnormal click, the normal sounds of gears must be understood. In pumps, certain pumps will have surges which may confuse inexperienced operators by the constant shifting of the meter readings. The surge pattern must be observed before a lower, consistent meter reading can be recognized as the true meter reading.

4. LOCATING FAULTY STEAM TRAPS

An ultrasonic test of steam traps is a positive test. The main advantage to ultrasonic testing is that it isolates the area being tested by eliminating confusing background noises. A user can quickly adjust to recognizing differences among various steam traps, of which there are three basic types: mechanical, thermostatic and thermodynamic. When testing steam traps ultrasonically:

1. Determine what type of trap is on the line. Be familiar with the operation of the trap. Is it intermittent or continuous drain?
2. Try to check whether the trap is in operation (is it hot or cold? Put your hand near, but do not touch the trap.)
3. Use the contact (stethoscope) module.
4. Set to LOG position in meter mode selection dial.
5. Position Frequency Adjust Dial to FIXED BAND.
6. Try to touch the contact probe towards the discharge side of the trap. Press the trigger and listen.
7. Listen for the intermittant or continuous flow operation of the trap. Intermittent traps are usually the inverted bucket, thermodynamic (disc) and thermostatic (under light loads). Continuous flow: include the float, float and thermostatic and (usually) thermostatic traps, While testing intermittent traps, listen long enough to gauge the true cycle. In some cases, this may be longer than 30 seconds. Bear in mind that the greater the load that comes to it, the longer period of time it will stay open.

   In checking a trap ultrasonically, a continuous rushing sound will often be the key indicator of live steam passing through. There are subtleties for each type of trap that can be noted.

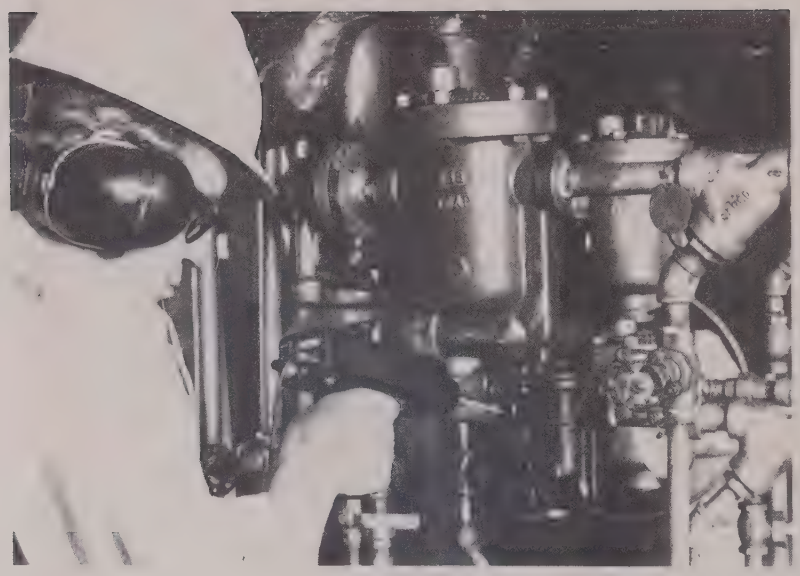
   Use the sensitivity levels of the Sensitivity Selection Dial to assist your test. If a low pressure system is to be checked, adjust the sensitivity UP toward 10; if a high pressure system (above 100 psi) is to be checked, reduce the sensitivity level. (Some experimentation may be necessary to arrive at the most desirable level to be tested.

FREQUENCY SELECTION

Occasionally it may be necessary to "tune in" to a steam trap. In some systems, specifically float type traps under low or moderate pressure load, a wide orifice will not produce too much ultrasound. If this is the case, touch the trap on the downstream side, reduce the frequency, start at 20 kHz and listen for a lower frequency trickling sound of water. For other subtle trap sounds, such as determining the difference of condensate vs steam sounds, try to listen at FIXED BAND. If this proves difficult, gradually rotate the Frequency Selection Dial down (counter-clockwise) until the specific sounds are heard. Steam will have a light, gaseous sound, condensate will have additional overtones to its rushing sound.

A FLOAT AND THERMOSTATIC trap normally fails in the "closed" position. A pinhole leak produced in the ball float will cause the float to be weighted down or water hammer will collapse the ball float. Since the trap is totally closed – no sound will be heard. In addition, check the thermostatic element in the float and thermostatic trap. If the trap is operating correctly, this element is usually quiet; if a rushing sound is heard, this will indicate either steam or gas is blowing through the air vent. This indicates that the vent has failed in the open position and is wasting energy.

THERMODYNAMIC (DISC) traps work on the difference in dynamic response to velocity changes in the flow of compressible and incompressible fluids. As steam enters, static pressure above the disc forces the disc against the valve seat. The static pressure over a large area overcomes the high inlet pressure of the steam. As the steam starts to condense, the pressure against the disc lessens and the trap cycles. A good disc trap should cycle (hold-discharge-hold) 4-10 times per minute. When it fails, it usually fails in the open position, allowing continuous blow-through of steam.



THERMOSTATIC TRAPS (bellows & bimettalic) operate on a difference in temperature between condensate and steam. They build up condensate so that the temperature of condensate drops down to a certain level below saturation temperature in order for the trap to open. By backing up condensate, the trap will tend to modulate open or closed depending on load.

In a bellows trap, should the bellows become compressed by water hammer, it will not function properly. The occurrence of a leak will prevent the balanced pressure action of these traps. When either condition occurs, the trap will fail in its natural position either opened or closed. If the trap fails closed, condensate will back up and no sound will be heard. If the traps fails open, a continous rushing of live steam will be heard.

With bimetallic traps, as the bimetallic plates take a set due to the heat they sense and the cooling effect on the plates, they may not take a set properly which will prevent the plates from closing completely and allow steam to pass through. This will be heard as a constant rushing sound.

5. FINDING FAULTY VALVES

Utilizing the contact (stethoscope) module in the Ultraprobe, valves can easily be monitored to determine if a valve is operating properly. As a liquid or gas flows through a pipe, there is little or no turbulence generated except at bends or obstacles. In the case of a by-passing valve, the escaping liquid or gas will go from a high to a low pressure area, thus creating turbulence on the low pressure or downstream side. This produces a white noise. The ultrasonic component of this "white noise" is much stronger than the audible component. Especially in minute leaks. If a valve is leaking internally, the ultrasonic emissions generated at the orifice site will be heard and noted on the meter. The sounds of a leaking valve seat will vary depending upon the density of the liquid or gas. In some instances it will be heard as a subtle crackling sound, at other times as a loud rushing sound. A properly seated valve will generate no sound. In some high pressure situations, the ultrasound generated within the system will be so intense that a sonic transference will occur, i.e.: sound will carry across the valve seat. In this case it is still possible to diagnose valve blow-up by comparing sonic intensity differentials between upstream and downstream readings.

PROCEDURE FOR VALVE CHECK:

1. use stethoscope module
2. select LOG in meter mode dial
3. start test in FIXED BAND on Frequency Selection Dial. If the sound appears weak or confusing, test at 40 kHz.
4. touch downstream side of valve and listen through headset.
5. when necessary, if there is too much sound, reduce sensitivity.
6. for comparative readings, usually in high pressure systems:
   a. touch upstream side and reduce sensitivity to minimize any sound.
   b. touch valve seat and/or downstream side.
   c. compare sonic differentials. If the valve is in a blow-by, the sound level on the seat or downstream side will be equal to or louder than the upstream side.
7. in some instances, such as in noisy background, it will be helpful to adjust the frequency to adequately interpret valve sounds. To do this:
   a. touch valve and gradually rotate Frequency Select Dial until the stray signals are minimized.
   b. touch the upstream side, valve seat, downstream side and compare differences.

6. MISCELLANEOUS PROBLEM AREAS

A. UNDERGROUND LEAKS

Underground leak detection depends upon the amount of ultrasound generated by the particular leak. Some slow leaks will emit very little ultrasound. Compounding the problem is the fact that earth will tend to insulate ultrasound. In addition, loose soil will absorb more ultrasound than firm soil.
If the leak is close to the surface and is gross in nature, it will be quickly detected. The more subtle leaks can also be detected but with some additional effort. In some instances it will be necessary to build up pressure in the line to generate greater flow and more ultrasound. In other cases it will be necessary to drain the pipe area in question, isolate the area by valving it off and inject a gas (air or nitrogen) to generate ultrasound through the leak site. This latter method has proven very successful.

PROCEDURE:

1. use contact (stethoscope) module.
2. adjust meter selection to LOG.
3. start in FIXED BAND in Frequency Selection. If water leak, use lower frequency such as 20 kHz.
4. touch surface over ground DO NOT JAM probe to ground. Jamming can cause probe damage.

4a. in some instances it will be necessary to get close to the "source" of the leak. In this situation, use a thin, sturdy metal rod and drive it down close to, but not touching, the pipe.
4b. touch the contact probe to the metal rod and listen for the leak sound.
4c. this should be repeated approximately every 5 feet until the leak sound is heard.
4d. to locate the leak area, gradually position the rod until the leak sound is heard at its loudest point.

B. LEAKAGE BEHIND WALLS

1. look for water or steam markings such as discolorations, spots in wall or ceiling, etc.
2. (if steam) feel for warm spots in wall or ceiling.
3. test area using steps 1-3 as outlined above.
4. listen for leak sounds. The louder the signal the closer you are to the leak site.

C. BLOCKAGE IN PIPES

If total blockage occurs in piping, there will be no sound since there will be no flow at the blocked site.

PROCEDURE:

1. use steps 1-3 as outlined in VALVE TESTING.
2. touch the pipe and listen for the drop in sound levels as the blocked site is approached.
3. If this proves difficult, use the Tone Test method:
   a. make sure the downstream side of the pipe is clear of fluids.
   b. place a Tone Generator in the downstream side facing upstream.
   c. at set intervals, touch along pipe with contact probe and listen for a drop off of the ultrasonic signal from the Tone Generator.

Partial Blockage:
When partial blockage exists, a condition similar to that of a by-passing valve is produced. The blockage will also generate ultrasonic signals. As an example, if a partial blockage is suspected, a section of piping should be inspected at various intervals. The ultrasound generated within the piping will be greatest at the site of a partial blockage.

PROCEDURE:

1. use procedures 1-3 as outlined in VALVE TESTING.
2. listen for an increase in ultrasound created by the turbulence of partial blockage.

FLOW DIRECTION

Flow in piping increases in intensity as it passes through a restriction or a bend in the piping. As flow travels upstream, there is an increase in turbulence and therefore the intensity of the ultrasonic element of that turbulence at the flow restriction. In testing flow direction, the ultrasonic levels will have greater intensity in the UPSTREAM side than in the DOWNSTREAM side.

PROCEDURE:

1. use stethoscope mode.
2. select LOG in Meter Selection Dial.
3. start test in FIXED BAND mode. If there is a difficulty in hearing the flow signal, adjust Frequency Selection Dial to 40 kHz.
4. begin test at 10 (maximum) sensitivity level.
5. locate a bend in the pipe system (preferably 60° or more).

6. touch one side of bend and note meter level.
7. touch other side of bend and note meter level.
8. the side with the higher (louder) reading should be the upstream side.

NOTE; Should it be difficult to observe a sound differential, reduce sensitivity and test as described until a sonic difference is recognized.

ULTRASOUND TECHNOLOGY

The technology of ultrasound is concerned with sound waves that occur above human perception. The average threshold of human preception is 16,500 Hertz. Although the highest sounds some humans are capable of hearing is 21,000 Hertz, ultrasound technology is usually concerned with frequencies from 20,000 Hertz and up. Another way of stating 20,000 Hertz is 20 kHz, or KILOHERTZ. One kiloHertz is 1,000 Hertz.

Since ultrasound is a high frequency, it is a short wave signal. Its' properties are different from audible or low frequency sounds. A low frequency sound requires less acoustic energy to travel the same distance as a high frequency sound. (Fig. A)

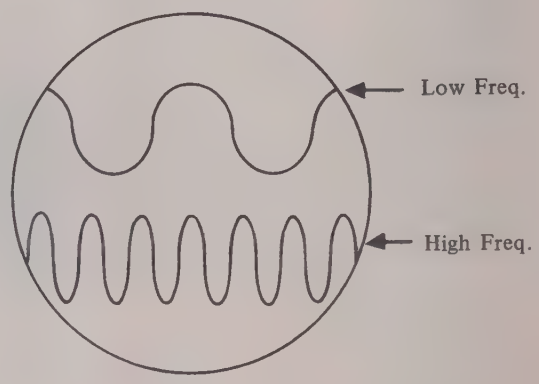


Figure A

The ultrasound technology utilized by the Ultraprobe is generally referred to as Air-borne ultrasound. Air-borne ultrasound is concerned with the transmission and reception of ultrasound through the atmosphere without the need of sound conductive (interface) gels. It can and does incorporate methods of receiving signals generated through one or more media via wave guides.

There are ultrasonic components in practically all forms of friction. As an example, if you were to rub your thumb and forefinger together, you will generate a signal in the ultrasonic range. Although you might be able to very faintly hear the audible tones of this friction, with the Ultraprobe it will sound extremely loud.

The reason for the loudness is that the Ultraprobe converts the ultrasonic signal into an audible range and then amplifies it. Due to the comparative low amplitude nature of ultrasound, amplification is a very important feature.

Although there are obvious audible sounds emitted by most operating equipment, it is the ultrasonic elements of the acoustic emissions that are generally the most important. For preventative maintenance, many times an individual will listen to a bearing through some simple type of audio pick-up to determine bearing wear. Since that individual is hearing ONLY the audio elements of the signal, the results of that type of diagnosis will be quite gross. The subtleties of change within the ultrasonic range will not be preceived and therefore omitted. When a bearing is perceived as being bad in the audio range, it is in need of immediate replacement. Ultrasound offers a predictable diagnostic capacity. When changes begin to occur in the ultrasonic range, there is still time to plan appropriate maintenance. In the area of leak detection, ultrasound offers a fast, accurate method of locating minute as well as gross leaks. Since ultrasound is a short wave signal, the ultrasonic elements of a leak will be loudest and most clearly perceived at the leak site. In loud factory type environments, this aspect of ultrasound makes it even more useful. Most ambient sounds in a factory will block out the low frequency elements of a leak and thereby render audible leak inspection useless. Since the Ultraprobe is not capable of responding to low frequency sounds, it will hear only the ultrasonic elements of a leak. By scanning the test area, a user may quickly spot a leak.

THE BASICS OF SOUND

"Sound" is defined as "Mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium (as air) and is the objective cause of hearing."

Ultrasound is high frequency sounds above human perception.

In order to understand the nature of sonic transmission and reception, it is important to know the basics of a sound wave. There are four basic components to a sound wave: amplitude, frequency, compression and refraction.

AMPLITUDE AND FREQUENCY

Imagine, if you would, a flexible steel plate (Fig. 1). The tip of the plate is pulled to position B and released. The plate will try to move back to resting position A but the force of the inertia of the movement will carry it past position A to the displacement position C. The energy created within the plate will attempt to again position itself at A but will move to B and so on until the force has weakened enough to slow down and rest at A. The oscillatory motion of the spring is called vibration. The motion of this oscillation may be viewed as a sine curve or displacement curve (Fig. 2).

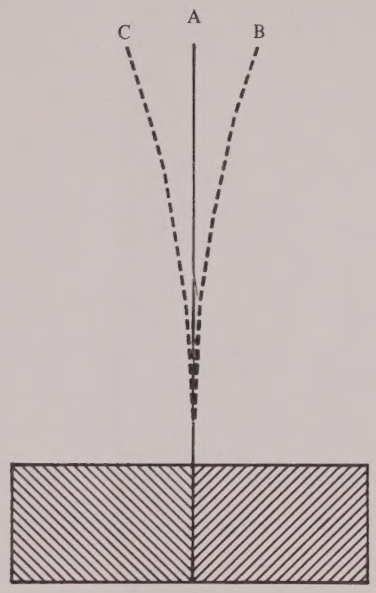


Figure 1

The sine wave represents the displacement of the steel spring to one side or the other of the rest point. The maximum displacement on either side of the point of rest is amplitude. This is represented by the distance between Aa or Cc.

The completion of one swing from rest point to rest point (x and y) is a cycle. Frequency is the number of complete cycles produced in one unit of time. In a less technical mode, AMPLITUDE can be thought of as volume, FREQUENCY can be thought of as pitch.

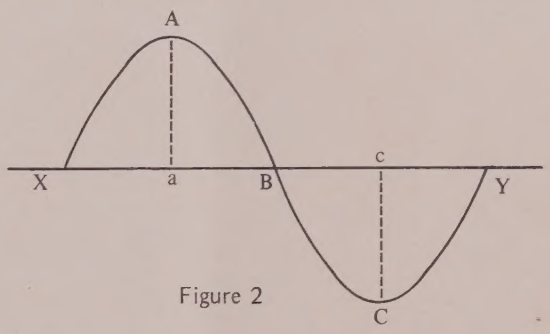


Figure 2

COMPRESSION AND RAREFACTION

Consider boxes attached by springs (Fig. 3).

A is pushed closer to B. Unequal stress is produced among the springs. In order to restore equilibrium, the stresses in A will be transferred to B, B to C and so on. This successive wave transfer is a "wave of compression."

The reverse movement, pulling away from the compression can be considered rarefaction or a "wave of rarefaction."

Just as with our steel spring, the compression in one box will rebound causing rarefaction and again compression. Each mass will alternately push and pull on either side of its normal point of rest until all the energy is lost. This mass of boxes can represent the minute particles of a gas or any elastic (sound conductive) substance in which sound waves may be set up.

Sound waves are made up of alternating waves of compression and rarefaction. The particles of the particular sound conductive medium oscillates back and forth, the resultant wave moves outward from the source, not in circles as in the case of waves of water, but in concentric spheres of alternating compression and rarefaction.

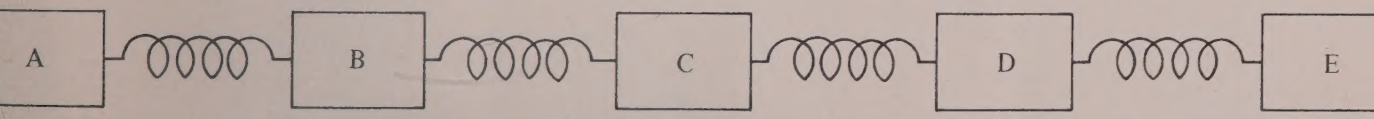


Fig. 3

REFERENCE GUIDE 1

DIAGRAM OF EQUIPMENT:

EQUIPMENT NAME:

LOCATION:

BEARING NUMBER _____					BEARING NUMBER _____					BEARING NUMBER _____					BEARING NUMBER _____				
DATE	FREQUENCY SETTING	SENSITIVITY SETTING	METER READING IN LINEAR MODE	READING TAKEN BY	DATE	FREQUENCY SETTING	SENSITIVITY SETTING	METER READING IN LINEAR MODE	READING TAKEN BY	DATE	FREQUENCY SETTING	SENSITIVITY SETTING	METER READING IN LINEAR MODE	READING TAKEN BY	DATE	FREQUENCY SETTING	SENSITIVITY SETTING	METER READING IN LINEAR MODE	READING TAKEN BY

ATTENUATOR TRANSFER CURVE

In order for the Ultraprobe to cover its extremely wide sensitivity range (from the minute ticking of a watch to the extreme sounds of high-speed bearings), it is necessary to use a specially tapered sensitivity setting curve. This means that a sensitivity setting of 8 is NOT twice as sensitive as setting 4 (the volume range of Ultraprobe is 1,000,000,000,000,000 to 1 !). The purpose of the Transfer Curve is to relate readings taken at different sensitivity settings.

to use Attenuator Transfer Curve:

1. Measure bearing using the LINEAR meter mode.
2. While touching bearing housing, reduce sensitivity level until the meter reads 50.
3. Make a permanent notation of this level for future reference on a chart.
4. Look for this sensitivity level on the left side of the chart.
5. Follow on a line directly across to the right side, until you reach the intersection of your sensitivity level with the curve; this is the decibel reading.
6. Note your decibel reading in the same chart as you have noted your sensitivity level.
7. In future tests repeat the above process.
8. Next, compare the decibel difference between the previous reading and the current reading.
9. When a good bearing increases by 10 to 20 decibels over its original value, this is warning of imminent failure.

Ultraprobe 2000

U.E. Systems Inc. 1995 Broadway, New York, N.Y. 10023 · 1-800-223-1325 · 212-787-1152 · Telex 238664